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AN INDICATOR MODEL OF CORE INFLATION IN CANADA

by

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Abstract

This paper presents an indicator, or non-structural, model of inflation in Canada that provides forecasts up to four quarters ahead. Our indicator model is not based on a tight theoretical foundation, but it incorporates most of the factors that are thought to cause inflation. The model also includes a leading index of inflation.

The predictive capability of our indicator model in forecasting future inflation is very good. The out-of-sample forecast errors for the 1988 Q1-1995 Q1 period were much smaller than forecast errors from either a Phillips Curve or autoregressive model of inflation. Our indicator model, which was developed using data through the fourth quarter of 1994, predicted reasonably well on average the movements in inflation that occurred during 1995.

Résumé

Ce document de recherche présente un modèle d'indicateur de l'inflation pour le Canada qui permet de construire des prédictions jusqu'à quatre trimestres à l'avance. Notre modèle d'indicateur n'est pas dérivé d'un cadre théorique traditionnel de l'inflation, mais il comprend la plupart des facteurs qui causent l'inflation. Le modèle comprend aussi un indicateur avancé de l'inflation.

La capacité de notre modèle d'indicateur à prédire l'inflation future est très bonne. Pour la période se situant entre le premier trimestre de 1988 et le premier trimestre de 1995, les erreurs de prédiction hors-échantillon ont été nettement plus petites que celles provenant d'un modèle de courbe de Phillips et d'un modèle univarié de l'inflation. Notre modèle d'indicateur, qui a été estimé avec des données se terminant au quatrième trimestre de 1994, a bien prédit en moyenne le mouvement de l'inflation en 1995.

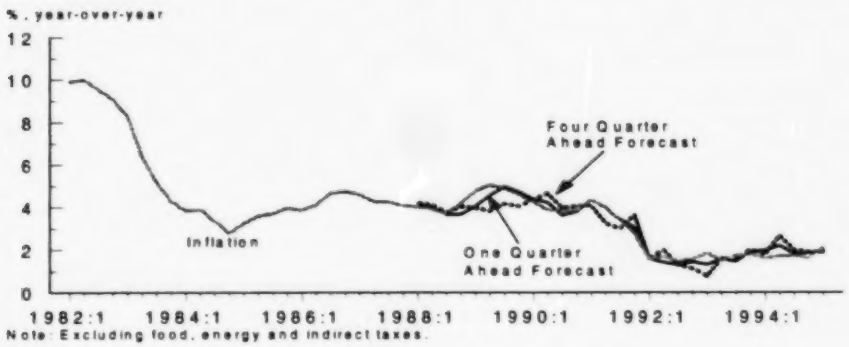
1 INTRODUCTION

Accurate forecasts of inflation are important. Government revenues depend on nominal values, and monetary policy is now explicitly formulated in terms of keeping inflation inside a narrow target band. Deriving more accurate forecasts of inflation, therefore, will allow for more accurate deficit forecasts and will prove useful in setting monetary policy.

This paper presents an indicator, or non-structural, model of inflation in Canada. It is inspired by recent work by Webb and Rowe (1995), Davis and Henry (1994), Stock and Watson (1989) and Klein (1986).

The model provides accurate out-of-sample forecasts over one to four quarters, as shown in the Chart 1 below.

Chart 1
Forecasts of Inflation: One and Four Quarter Ahead



Note: Excluding food, energy and indirect taxes.

The novelty of the model is that it includes a leading index of inflation among the explanatory variables. We found the leading index to be highly correlated with the measure of the output gap from the Department of Finance macroeconomic model, but to have greater explanatory power in predicting future inflation in the context of our model. Another clear advantage of using a leading index of inflation in a short-term forecasting model is that, unlike the output gap, it is not subject to substantial revision or judgement.

Although the indicator approach used here does not seek to "explain" inflation so much as to capture its evolution over short time horizons, we find that the indicator model includes most of the channels that are thought to cause inflation, including capacity pressures, wages, and imported inflation. The indicator model is offered as an adjunct to, not a replacement for, the structural models of inflation that the Department of Finance already possesses.

The paper is organised as follows. Section II describes the model and discusses a number of issues associated with its design and interpretation.[1] Section III examines the model's predictive capacity and compares it to that of a Phillips Curve model as well as an autoregressive model of inflation.[2] Section IV explains how the leading index of inflation, a key variable of the model, was derived.

II AN INDICATOR MODEL OF INFLATION

This section first motivates and describes the indicator model of inflation, and then shows how it manages to encompass most of the factors which are thought to cause inflation. Subsequently, we discuss how the model is manipulated to forecast future inflation and examine the contribution of the different explanatory variables to that forecast.

II.1 DESCRIPTION OF THE INDICATOR MODEL

It is widely accepted in the economics literature that forecasting the rate of inflation is very difficult and that there is no consensus among economists about the short-run determinants of inflation. For example, Cecchetti (1995) has recently concluded that "inflation is extremely difficult to forecast at horizons of even one quarter."[3] The recent inflation experience in Canada is consistent with this view -- forecasters did not predict the increase in the rate of inflation that occurred in 1995.

The Economic and Fiscal Policy Branch of the Deparment of Finance has two structural inflation models, which were not explicitly built to capture short-term developments.[4] The indicator, or non-structural, approach may help predict short-term movements in inflation. The approach we have chosen was to first built a leading index of inflation and, then, develop an indicator model of inflation using the leading index as one the explanatory variables. This strategy results in a very

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[1] The model is presented first, because the main goal of our research was to forecast the level of future rates of inflation.

[2] The forecasting performance of the indicator model was not compared to the Department of Finance macroeconomic model, because it is not possible to make a useful comparison given how the last model works. The indicator model uses only information that is observed at the time that the forecast is made. The Department of Finance macroeconomic model also requires forecasts of the exogenous variables in the model.

[3] In their study of inflation Bryan and Cecchetti (1993) conclude: "we confirm the general impression that it is difficult to forecast inflation", p. 18. Ball and Mankiw (1995) write: "What determines inflation? Most macro economists agree that, in the long run, the primary determinant of inflation is the money supply. The short-run behaviour of inflation, however, is more controversial.", p. 161.

[4] See Lavoie (1994) and Robidoux (1992). Lavoie's(1994) model is a reduced form model based on a Phillips Curve framework. The price equations of the Department of Finance macroeconomic model are explained in Robidoux (1992).

parsimonious model and it was also the one which yielded the best predictive performance.

The indicator model was designed to predict the ´core´ rate of inflation in Canada. More specifically, the dependent variable of the model is defined as the year-over-year percentage change in the consumer price index excluding food, energy and indirect taxes -- the so-called Net Price Index (thereafter NPI).[5] The choice of the dependent variable was dictated by a number of factors. The all-items CPI is often affected by temporary and unexpected changes in food and energy prices. As a result, it can provide misleading indications about the ´core´ rate of inflation. Similarly, there have been important changes in indirect taxes in the past, such the introduction of the Goods and Services Tax in January 1991 and the tobacco tax cuts in February 1994, which could significantly alter the dating of the inflation cycle.[6] For similar reasons, the Bank of Canada considers the NPI to be the best indicator of ´core´ inflation, and uses that variable to assess how inflation is evolving relative to the government's inflation targets.

The indicator model includes four exogenous variables, which are $\dot{p}_{t-k}$ the lagged NPI rate of inflation; lii_{t-k} a leading index of inflation[7], $w_{t-k,}$ the base wage rates contained in wage settlements, $\dot{p}^{f}_{t-k}$ the US 'core' inflation[8] expressed in Canadian dollars and d_{gst} a dummy variable to capture effects of the GST not reflected by the estimated values in the NPI.[9] All the variables are stationary (I(0)) based on the Augmented Dickey-Fuller test.

The indicator model was estimated using ordinary least squares.[10] The estimation period was deliberately chosen to overcome specification problems encountered when modelling series with structural breaks. Perron (1993) has shown that Canadian inflation contains at least one

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5 The NPI is available monthly starting in 1984. The NPI index is not seasonally adjusted.

6 The impact of these three factors on total CPI inflation rate is discussed in the *Bank of Canada Review*, September 1991. It is also interesting to note that these three factors tend to make the identification of the data generating process of total CPI inflation much more difficult.

7 See Section IV for more details on the leading index of inflation and how it was constructed.

8 Expressed as the year-over-year per cent change in the CPI, excluding food and energy.

9 The dummy variable takes on a value of 1 in 1991 Q1 and -1 in 1992 Q1. This is consistent with the notion that the FST savings were passed through to consumers over the course of 1991, and not entirely in the first quarter of the year as assumed in the calculation of the NPI.

10 As indicated by Pagan (1984), the estimation of a model containing a generated regressor, such as a Phillips Curve model, by OLS will lead to estimated standard errors inconsistent with the true standard errors. This means that test statistics based on these standard errors are biased and can lead to incorrect inferences. In our case, the leading index of inflation is not a generated regressor. The leading index is composed of four observable economic variables and it does not depend on estimated coefficients to aggregate the components. Instead, the leading index is a normalized sum of four observed variables.

such break. Starting in the early 1980s the inflation regime changed as monetary authorities successfully pursued a policy of stable inflation.[11] This was in contrast with the experience of the 1970s when no such stability in the rate of inflation was apparent. Our choice of sample period, therefore, is inspired by Perron's (1993) recommendation to "permit different correlation structures across different [inflation] episodes".[12] Accordingly, the model was estimated from 1982 Q1 to 1994 Q4, a period in which it is generally accepted that the rate of inflation was stationary.

The regression results for the indicator model are given below.

$$[1]\quad \dot{p}_t = \underset{(-6.40)}{-18.63} + \underset{(14.12)}{0.67}*\dot{p}_{t-1} + \underset{(6.50)}{0.19}\,lii_{t-5} + \underset{(3.54)}{0.13}*\dot{w}_{t-1} + \underset{(3.90)}{0.04}*\dot{p}^{f}_{t-6} + \underset{(3.56)}{0.71}*d_{gst}$$

$$\bar{R}^2 = 0.98, \quad S.E.E = 0.27, \quad \sigma_{\dot{p}_t} = 2.11$$

Note: $\bar{R}^2$ the adjusted multiple correlation coefficient, S.E.E. the standard error of the regression and σ_p the standard error of the dependent variable. The student's *t* statistics are in parentheses.

The actual and fitted values and the residuals of the model are plotted in Chart 2. The model captures the movements in inflation well. The residuals are well behaved without any persistent tendency to under- or over- predict. Diagnostic tests are reported in Table 1. They show that the residuals are *iid*-N(0, σ^2). Recursive stability tests suggest that the coefficients are stable (see Charts A.1 to A.6 in Appendix 1). Finally, the model is very robust to changes in the sample estimation period, even for large changes which leave very few degrees of freedom.[13]

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[11] For example, Perron (1993) found that the degree of price stabilization in Canada "has varied a great deal over the post war period, being almost null in the 1973-81 period but being close to perfect in the period from 1982 to present." This conclusion has also been verified by at least two other studies conducted by the Bank of Canada (Laxton, Tetlow & Rose (1993), and Hostland (1995)).

[12] By restricting the sample period to one inflation regime we are also abiding with Sims' (1989) recommendation to use time varying coefficients to adapt to changing economic environment -- albeit in very crude fashion.

[13] The exception to the generally robust econometric properties of the model is that higher orders of the Ramsey RESET test suggest that there is a specification problem. However, we are inclined to discount this result as there is no evidence of specification error in any of the other tests performed. For example, if there was a specification error we would expect this to translate into parameter instability. Also the Ramsey test result is very sensitive to the estimation period. For example, starting the estimation just one quarter later (in 1982:Q2) results in the test statistic easily rejecting the null hypothesis of misspecification with three lagged fitted values included in the test.

CHART 2

ACTUAL AND FITTED VALUES AND RESIDUALS FROM THE INDICATOR MODEL OF INFLATION

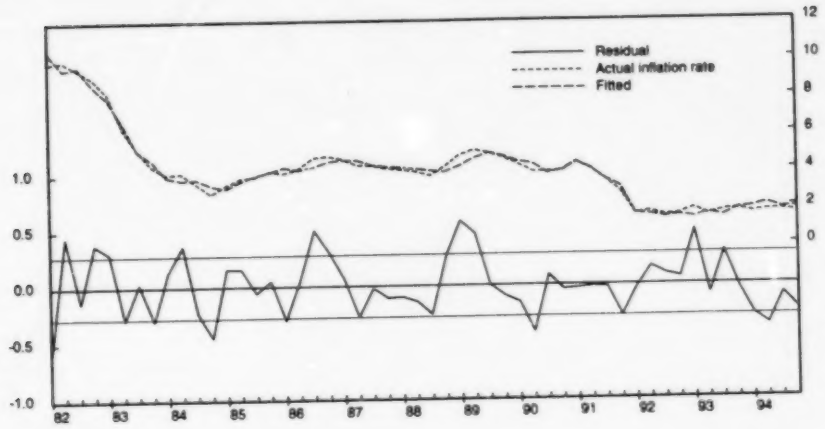

TABLE 1: DIAGNOSTIC TESTS ON THE RESIDUALS

Test	1st Order (p-values)	2nd Order (p-values)	3rd Order (p-values)	4th Order (p-values)
LM Test	0.47	0.75	0.61	0.28
ARCH Test	0.41	0.99	0.87	0.76
RESET test	na	0.91	0.02	0.05
J-B test	0.58			
White Test	0.34			

As the leading index of inflation is the sum of four measured variables, we can interpret the use of the leading index as an independent variable as imposing a restriction on the model, specifically, that the coefficients on each of the variables that make up the leading indicator are equal. That restriction was tested, and not rejected. Moreover, relaxing the restriction did not improve the forecasting performance of the model.

Numerous other variables were tested for inclusion in the model, but found to have no significant additional explanatory power. These included different measures of: foreign prices, interest rates, the yield curve, monetary aggregates (including the spread between different monetary aggregates and nominal GDP growth) and excess demand measures, (such as the output and labour gaps from the Department of Finance macroeconomic model, the rate of capacity utilisation and the unemployment rate).

At face value, the indicator model is significantly different from standard theoretical models of inflation which are normally based on some measure of the output gap (either directly or via the influence of wages). However, on closer inspection, the indicator model appears to capture most of the influences on inflation found in more traditional approaches. In particular, the leading index of inflation has greater explanatory power than any measure of excess demand in the economy. When either the output and labour gaps from the Department of Finance macroeconomic model, the non-farm industrial capacity utilisation rate or the unemployment rate were added to the model (with the leading index of inflation included), their respective estimated coefficients were found to be not significantly different from zero at 5 per cent. Substituting only the output gap (a generated regressor) for the leading index of inflation in [1], resulted in an equation with strong first order serial correlation of the residuals and lower explanatory power. This suggests that the leading index of inflation captures everything that the output gap has to offer in explaining short-term inflation.

To our knowledge, this is the first time that a leading index of inflation has been found to have strong predictive capacity. A recent study by Garner (1995) has documented that all publicly available leading indexes of US. inflation do not add any information to standard models of inflation. Garner (1995) concludes: "[leading] indicators have typically not added useful predictive information to a standard model of consumer price inflation that includes economic slack and past inflation."[14]

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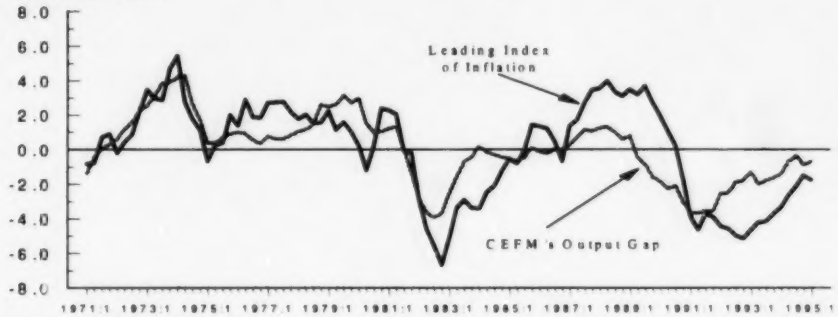
[14] C.A. Garner (1995), p 15.

How do we interpret the greater predictive power of the leading index of inflation over more standard measures of excess demand? Output gaps, such as the one calculated in the Department of Finance macroeconomic model, are opened and closed largely according to cyclical changes in demand (given trend potential output growth). The leading index of inflation was designed primarily to provide a broadly-based gauge of demand pressures in the economy (more particularly in labour, commodities and capital markets). Chart 3 shows that since the early 1970s, the leading index has moved in broadly similar fashion with the output gap from the Department of Finance macroeconomic model.

Chart 3
Leading Index of Inflation and Output Gap
normalized values



Note: Means of both series were normalized to zero.

In very general terms, the leading index of inflation can be considered as an alternative approximation to the output gap, but measured on the basis of variables which are not subject to substantial revisions or retrospective judgement. This is potentially an important contribution as historical estimates of excess demand have been subject to considerable revision, which altered our view of the extent of inflationary pressures in the economy. For example, current estimates of the output gap indicate that in the late 1980s the economy was overheating to a much greater extent than we formerly believed.[15]

More generally, of the seven variables in the indicator model (there are actually four variables in the model, but the leading index of inflation is also comprised of four variables) only three are subject to revision. These two are household debt, profit margins and commodity prices, which are components of the leading index of inflation. The other variable included in the leading index, the Help Wanted Index (not seasonally adjusted), is not subject to revision. Similarly, the Canadian dollar price of U.S. 'core'

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[15] Output gap measures are also revised when economic data are revised. But, output gap measures are sometimes re-estimated to account for ex post inflation developments, this makes its inferior explanatory power all the more surprising.

inflation is not revised, nor -- for the most part -- are the wage settlements data.[16]

II.2 Forecasting with the Indicator Model of Inflation

In the interest of efficiency we adopted the strategy of identifying the best model of inflation one quarter ahead and then modifying that model to forecast over longer time periods. An alternate procedure would have been to search for the best model to forecast inflation at different horizons. This alternate strategy could have required significantly more resources, without necessarily providing a markedly superior predictive capacity.

The indicator model described in the preceding section can easily be used to forecast one-quarter ahead as the explanatory variables enter the model lagged at least one quarter. To predict two to four quarters ahead, the lags on both the lagged dependent variable and on wage settlements will be increased as required.[17] The models are then re-estimated to determine the parameter values consistent with the different lag structures. This particular forecasting strategy contrasts with the structural approach which uses the predicted values of the explanatory variables to forecast ahead as many periods as required. Our strategy has the primary advantage that future forecast errors will not be subject to errors in the predicted values of the explanatory variables. Thus, the one to four-quarter ahead forecasts ($\hat{\dot{p}}_{t+k}, k = 1,2,3 \; and \; 4$, where k is the forecast horizon), will use the following variants of the model described in Section II:

$$[1.a] \quad \hat{\dot{p}}_{t+1} = f_1\left\{\dot{p}_t, \; lii_{t-4}, \; w_t, \; \dot{p}^f_{t-5}, \; d_{gst}\right\},$$

$$[2] \quad \hat{\dot{p}}_{t+2} = f_2\left\{\dot{p}_t, \; lii_{t-3}, \; w_t, \; \dot{p}^f_{t-4}, \; d_{gst}\right\},$$

$$[3] \quad \hat{\dot{p}}_{t+3} = f_3\left\{\dot{p}_t, \; lii_{t-2}, \; w_t, \; \dot{p}^f_{t-3}, \; d_{gst}\right\},$$

$$[4] \quad \hat{\dot{p}}_{t+4} = f_4\left\{\dot{p}_t, \; lii_{t-1}, \; w_t, \; \dot{p}^f_{t-2}, \; d_{gst}\right\}.$$

Increasing the lags on variables as required does not alter the signs of the estimated coefficients and they all remain highly significant.

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[16] The wage settlements data may be subject to minor revisions as these include settlements with COLA clauses, which require estimates of future inflation to calculate the effective increases in base wages. These are eventually revised once actual inflation is known. However, the incidence of COLA clauses has recently diminished considerably and most are rarely triggered at inflation rates as low as the current one, so we do not expect much revision due to this factor.

[17] This strategy was used in a recent study published in the Bank of Canada Review. See Clinton (1995).

Also, the models [2] to [4] still explain most of the variance of the dependent variable. However, this procedure does affect the parameter estimates considerably -- so the dynamics of the model differ according to the length of the forecast period.

The contribution of the explanatory variables across different forecast horizons is shown in Table 2, along with the standard errors of each model. As variables enter the model as percentage changes (with the exception of the leading index which enters in level form) the estimated coefficients can be interpreted as short-run semi-elasticities. For example, in the four-quarter-ahead forecast (model [4]), an increase in wage settlements of one percentage point would raise the forecast of inflation by 0.33 percentage points, everything else being equal.

TABLE 2:
CONTRIBUTION OF EXPLANATORY VARIABLES IN EXPLAINING FUTURE INFLATION

	1 Quarter	2 Quarters	3 Quarters	4 Quarters
Lagged inflation	0.67	0.44	0.28	0.20
Leading Index	0.19	0.39	0.45	0.59
Wage Settlements	0.13	0.22	0.29	0.33
U.S. Inflation in $CAN	0.04	0.07	0.07	0.07
S.E.E	0.28	0.33	0.39	0.42

The key difference between forecasting one-quarter ahead and at longer horizons is that the lagged dependent variable dominates the model at the one-quarter ahead horizon but its influence declines at longer horizons. For example, in the four-quarter ahead model, the lagged dependent variable plays a minor role, while the leading index of inflation and wage settlements dominate the model.[18] This change in the dynamic structure at different forecast horizons is consistent with the fact that there is significant persistence in inflation at short horizons.

[18] The constant term in the equations may seem large. However, this is because the leading index is expressed in terms of levels, while all other variables enter in percentage changes.

III FORECASTING PERFORMANCE OF THE INDICATOR MODEL

Two simulation exercises were conducted to evaluate the forecasting performance of the indicator model of inflation. First, we assessed the out-of-sample predictive capacity of the model at forecast horizons of one to four quarters. Second, the forecasting ability of the indicator model was compared to two alternative models of inflation: a Phillips Curve model and an autoregressive model.

III.1 OUT-OF-SAMPLE FORECASTING PERFORMANCE

As alluded to in section II, the lags on a number of variables in the model must be increased successively to extend the forecast horizon. Thus, four versions of the model are estimated to produce forecasts one to four quarters ahead.

To assess the out-of-sample forecasting ability of the model, we conducted recursive forecasts based on a rolling regression technique, starting in the first quarter of 1988. We then increased the estimation period by one quarter and produced another set of four forecasts as of the second quarter of 1988. Once we had forecast through the first quarter of 1995 we were able to compile the forecasts at different horizons into four time series to assess the accuracy of the indicator model across these horizons in predicting future inflation.

The forecast period was chosen to see how the model performed over the period of disinflation that started in 1989 and continued through late 1991. In order to capture this period the initial parameter estimates relied upon very few degrees of freedom. In these extreme cases, the parameter estimates remained very stable -- which is a strong indication that the specification is robust.

Out-of-sample forecast performance of the indicator model is illustrated in Charts 4(a) to 4(d). The charts indicate that the model accurately predicted all major turning points in inflation since 1988 -- including the recent increase in the first quarter of 1995. Further, the mean absolute errors of these forecasts are only moderate, ranging from 0.26 percentage points for the one-quarter ahead forecast to 0.55 percentage points for the four quarter-ahead forecast. While non-trivial in relation to the inflation target range of two percentage points, these errors are quite small in the realm of inflation forecasts.

Chart 4(a)
Indicator Model of Inflation:
One-Quarter Ahead Ex Ante Forecasting Performance

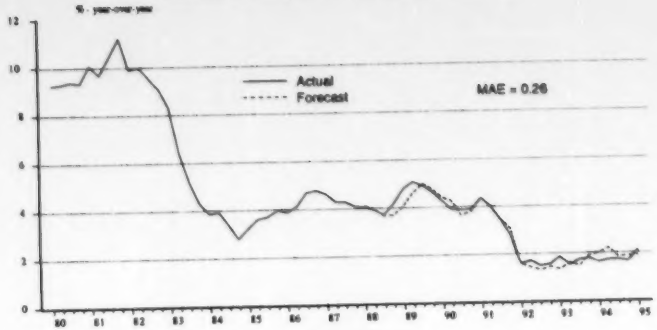


Chart 4(b)
Indicator Model of Inflation:
Two-Quarter Ahead Ex Ante Forecasting Performance

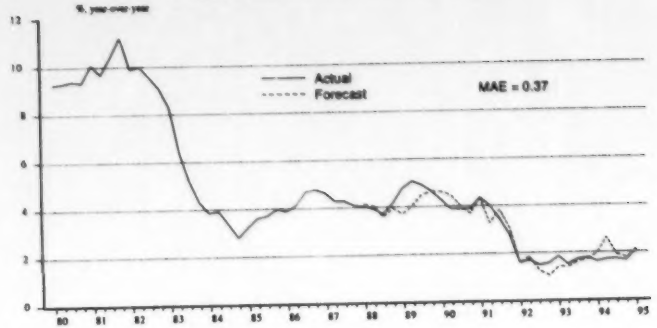


Chart 4(c)
Indicator Model of Inflation:
Three-Quarter Ahead Ex Ante Forecasting Performance

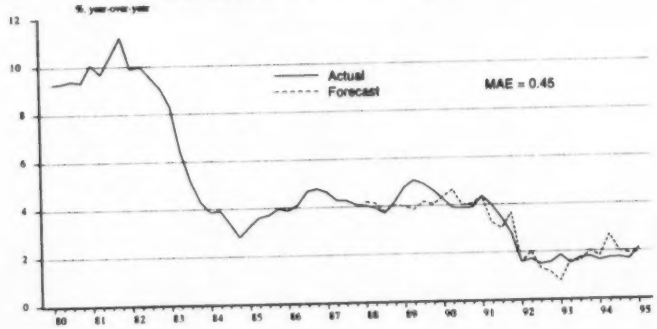
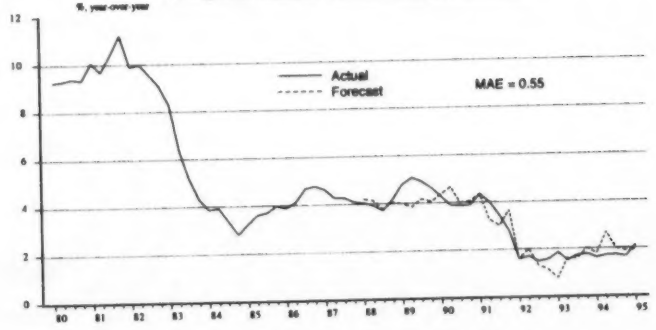


Chart 4(d)
Indicator Model of Inflation:
Four-Quarter Ahead Ex Ante Forecasting Performance



III.2 Forecasting Performance Relative to Other Models

The out of sample predictive capacity of the indicator model was compared to two alternative models of inflation: a Phillips Curve model and an autoregressive model of order two.[19] The last two models are described briefly below:[20]

$$[5] \quad \dot{p}_t = \beta_0 + \sum_{i=1}^{6} \beta_{1i} \dot{p}_{t-i} + \beta_2 \left(y_{t-4} / y^p_{t-4} \right)$$

$$[6] \quad \dot{p}_t = \beta_0 + \beta_1 \dot{p}_{t-1} + \beta_2 \dot{p}_{t-2}$$

where $\dot{p}_t$ represents the rate of inflation excluding food, energy and the effects of indirect taxes and $\left(y_t / y^p_t \right)$ the output gap from the Department of Finance macroeconomic model, measured as the ratio of the levels of actual to potential output. Coefficients β_{1i} are constrained to sum to 1.

The forecasting performance of the indicator model of inflation relative to the two models specified above was assessed at horizons of one to four quarters ahead. This simulation was carried out from the first quarter of 1988 to the first quarter of 1995. As explained in section II.2, a rolling regression technique was used to compute the predicted recursive values for each model at different forecast horizons. In similar fashion to the strategy used to forecast with the indicator model, the lags of the explanatory variables in models [5] and [6] were extended to compute the predicted values.

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[19] The predictive capacity of the indicator model of inflation was not compared to that of Department of Finance macroeconomic model, because the latter was not capable to predict from time t to t+4 using only economic data up to time t.

[20] We do not report the estimation results of these two equations, but they are available on request from the authors. The specification of the AR(2) model followed standard procedures of identifying the time series representation of a variable. These procedures included analysis of the autocorrelation and partial autocorrelation coefficients, estimation of a number of potential time series representations (with a view to keeping the specifications as parsimonious as possible), analysis of the residuals of these specifications and finally choosing among the potential models according to which provided the most accurate forecasts.

The Phillips Curve specification was determined according to a top-down approach. Starting with a very general model, insignificant parameters were successively eliminated. Note that the Phillips curve model is estimated starting in 1971 as the output gap is not significant in explaining inflation in the 1980s and 1990 alone. There is strong evidence of heteroskedasticity in the residuals of this model, which is a problem common to Phillips Curve models and is apparent in work by both Hostland (1995) for Canada and Webb (1995) for the United States.

The relative performance of each model was assessed in terms of the mean absolute errors and root mean square errors of the forecasts. Table 3 presents the results.

TABLE 3

OUT- OF -SAMPLE FORECAST ERROR STATISTICS FOR THREE MODELS OF INFLATION: 1988 Q1 - 1995 Q1

	Indicator Model		Phillips Curve Model		Autoregressive Model	
Forecast Horizons (in quarters)	Mean Absolute Error	Root Mean Square Error	Mean Absolute Error	Root Mean Square Error	Mean Absolute Error	Root Mean Square Error
One	0.26	0.34	0.42	0.48	0.28	0.37
Two	0.37	0.46	0.44	0.60	0.45	0.60
Three	0.45	0.58	0.59	0.84	0.60	0.81
Four	0.55	0.71	0.78	1.08	0.79	1.03

The first point of note is that the indicator model provides slightly more accurate one quarter ahead forecast than the autoregressive model,[21] and much better than a Phillips Curve model. Second, the out-of-sample predictive capacity of the indicator model, relative to the other two models, improves significantly as the forecast horizon is extended. Four quarters ahead, the indicator model's mean absolute error is about 0.5 percentage points, which is about one-third less than the two alternative models. Note that these tests provide the Phillips Curve model with an advantage because they are based on an output gap which has been estimated ex post. Estimating the models in real time would almost certainly increase the forecast error of the Phillips Curve in relation to the other two representations. It is unlikely that a more sophisticated Phillips Curve model would have changed these results significantly as both Hostland (1995) and Webb (1995) show that for both Canadian and U.S. data respectively that the predictive capacity of Phillips Curve models of inflation are very similar to autoregressive representations. Our results suggest that the indicator model of inflation is clearly the preferable model for forecasting inflation up to one year in advance.

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[21] An autoregressive model of inflation will usually do well in forecasting one period ahead because of the presence of a strong persistence in the inflation process, although these models usually miss cyclical turning points.

IV A LEADING INDEX OF INFLATION FOR CANADA

The construction of leading indexes started in the early 1940s with the pioneering work of A.F. Burns and W.C. Mitchell. Since then, national agencies of the G-7 members countries, such as the United States and Canada, have developed and regularly published leading indexes of economic activity.[22] These leading indexes were primarily built to provide early signals of turning points in the business cycle.

Cyclical patterns in the economy, however, are not just restricted to time series such as consumption, investment, labour, inventory and production. As indicated in Moore (1983), prices are also cyclical. Thus, in principle a leading index of inflation could be developed to provide advance signals of the cyclical peaks and troughs in inflation, similar to the indexes used to monitor aggregate economic activity. In early 1980s, Moore and Kaish (1983) built the first leading index of inflation for the U.S. economy. Since their path breaking study, other leading indexes of inflation have been developed to signal in advance cyclical changes in inflation for industrialised countries (see Klein (1986)).

This section explains how the quarterly leading index of inflation in Canada was constructed and assesses its usefulness in providing early signals of peaks and troughs in the inflation cycle.[23] The first part of this section will describe the inflation cycle chronology. The second part will explain how the leading index of inflation was developed. The last part will evaluate the performance of the index.

IV.1 INFLATION CYCLE CHRONOLOGY

The first step in developing a leading index is to establish the chronology of cyclical turning points.[24] This step is important because the chronology will subsequently be used to determine the components of the leading index, and to assess the extent to which the leading index provides advance signals of cyclical turning points in inflation.

As previously explained, we use the quarterly percentage change from year ago for NPI less food, energy and indirect taxes as the relevant

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[22] The most widely followed leading index is the U.S. Commerce Department's leading index of economic activity.

[23] To our knowledge, Klein (1986) developed the first leading index of inflation for Canada. Nesbitt Burns, a Canadian brokerage firm, also recently developed a leading indicator for inflation for Canada. A study of the performance of that leading indicator by St-Cerny (1995) concluded it was not reliable, gave false signals and had zero information content for predicting future inflation.

[24] The business cycle consists of periods of contraction and expansion in the level of aggregate economic activity. In contrast, the inflation cycle consists of periods of increasing and decreasing rates of inflation.

measure of inflation in Canada. Recall that the NPI was chosen because we believe that it provides the best indication of underlying inflation and is the measure consistent with the government's inflation targets. This is in contrast to Klein (1986) and Nesbitt Burns (1994), who both used the all-items CPI as the coincident indicator of inflation.

Unlike business cycle dating, for which a chronology is provided by Cross (1989), no official chronology of the inflation cycle is available. However, a number of rules have been established in the literature for this purpose (see for example Roth (1991)) which we have adopted in dating the Canadian inflation cycle. The key rule is that a change in the inflation cycle must involve a change in the rate of inflation of at least 1½ percentage points over a period of at least six months.

Chart 5 on the next page shows the rate of inflation, along with the proposed cycle chronology. The shaded areas correspond to periods of declining inflation. Cyclical peaks in the rate of inflation are indicated by the left-hand edges of the shaded blocks, while cyclical troughs are indicated by the right-hand edges. Further details about the characteristics of the inflation cycle are provided in Table 4 next page.

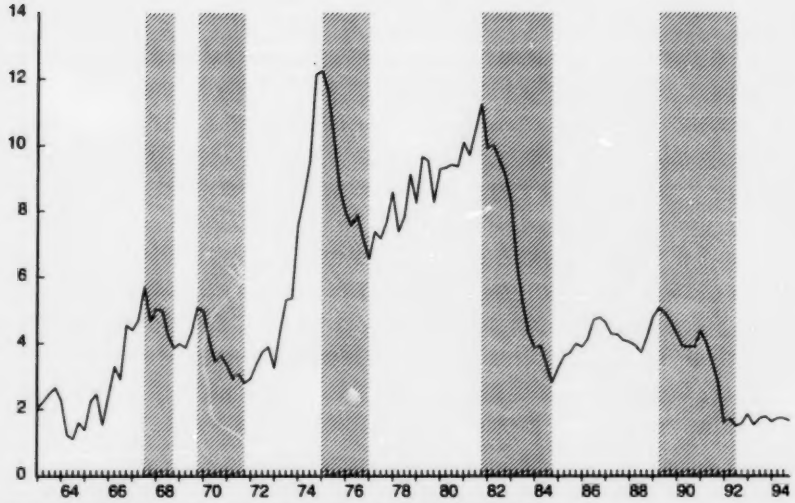
We have identified five inflation cycles since the mid-1960s. As is the case for business cycles, the inflation cycles vary in amplitude. For example, the increases in the inflation during periods of rising inflation vary from 1.3 to 9.4 percentage points. About the same spread was found for periods of declining inflation. The duration of the cycle also varies, ranging 4 to 19 quarters for expansions and from 5 to 13 quarters for contractions. It is interesting to note that, on average, a contraction in the rate of inflation will last a year less than a period of expansion. This means that the rate of inflation falls faster that it increases (given that inflation at the end of the period is equal to its level at the start of the period).

In summary, we have proposed a cycle chronology for inflation in Canada which will be used to identify leading indicators of inflation. The next sub-section will summarise the construction of the leading index of inflation.

CHART 5

INFLATION CYCLE CHRONOLOGY

(year-over-year percentage change)



Note: Inflation rate excluding food, energy and the effects of indirect taxes.
The shade bars show the inflation cycle chronology.

TABLE 4:

CYCLICAL TURNING POINTS IN THE INFLATION CYCLE

Troughs		Peaks		Change in inflation during preceding		Duration in quarter of preceding	
Quarter	Rate	Quarter	Quarter	Expansion	Contraction	Expansion	Contraction
		1967 Q3	5.7	-	-	-	-
1968 Q4	3.8	1969 Q4	5.1	+1.3	-1.9	4	5
1971 Q4	2.8	1975 Q2	12.2	+9.4	-2.3	13	8
1977 Q1	6.5	1981 Q4	11.2	+4.3	-5.7	19	8
1984 Q4	2.8	1989 Q3	5.1	+2.7	-9.4	18	12
1992 Q3	1.5				-3.6	11	13
Mean						**13**	**9**

IV.2 A Description of the Development of the Leading Index of Inflation

The theory of prices suggests that increases in prices generally reflect an economy-wide tightening in supply and demand. Initially we inspected about fifty quarterly economic time series which could provide early signals of emerging inflation pressures in the economy. They were classified in terms of demand pressure indicators, labour market indicators, commodity market indicators, and financial market indicators.

First, a graphical study of the relationship at cyclical turning points between the inflation cycle and each of the potential components was conducted. The components which were eventually included in the leading index were selected according to the following criteria, developed by Neftci (1991):

- Firstly, the components should be not be dominated by irregular movements;

- Secondly, the components should encompass a variety of influences on inflation across different markets; and

- Thirdly, the lead time of the components relative to peaks and troughs in the inflation cycle should be as long as possible so that the upcoming turning points in inflation are signalled as early as possible.

Two other criteria were used to select the components: they should be available promptly and subject to few significant revisions over time.

The leading index of inflation consists of four components that lead the inflation cycle:

- growth in the help wanted index,[25]
- growth in personal sector debt,
- growth in the Bank of Nova Scotia Commodity Price Index and
- profits as a share of gross domestic product.

All the components were available quarterly from the early 1960s and the leading index was developed from first quarter 1964 to the fourth quarter of 1994. The first three components represent respectively the intensity of demand in commodity, labour and capital markets (Moore and Kaish (1983 and Klein (1986)). The last component, profits as a share of gross domestic product, captures the longer term influences of change in the user cost of capital and in financing costs on inflation.

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[25] Growth is expressed on a year-over-year basis.

The selected components were then combined to create a leading index of inflation. Our procedure involves several algebraic operations on both the individual components and the leading index itself.[26] Briefly the procedure involves the following steps:

- The components were transformed and scaled so that their respective means were equal to the mean of the change in the rate of inflation.
- The components were aggregated into a fixed-weight index, using equal weights.[27]
- The leading index was formed by cumulating the fixed-weight index and then scaling this cumulated series so that its value in 1986 was equal to 100.

IV.3 Correlation of the Leading Index with Inflation Turning Points

The leading index of inflation, along with the inflation cycle chronology, is illustrated in Chart 6 next page. Table 5 includes data pertaining to the historical performance of the leading index in signalling cyclical peaks and troughs in inflation in advance.

The leading index provides a early signal of the cyclical turning points in inflation (see Chart 6). The lead of the index in signalling peaks in inflation varies from 2 to 9 quarters (see Table 5), with an average lead of 5 quarters. This is considerably larger that the average lead of the Nesbitt-Burns Leading Index or of Klein's (1986) index.[28] The leads at signalling cyclical troughs in inflation ranged from 3 to 9 quarters, with a mean of 6 quarters. Again, the average lead at trough is much larger than reported for the Nesbitt-Burns index and Klein (1986). In general, the leading index was successful in signalling significant changes in inflation over the last thirty years.

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[26] In early 1970s, a procedure was established by the U.S. National Bureau of Economic Research to construct a leading index of economic activity. The most widely followed leading index of inflation in the United States is produced by Geoffrey Moore and his associates at Columbia University's Centre for International Business Cycle Research.

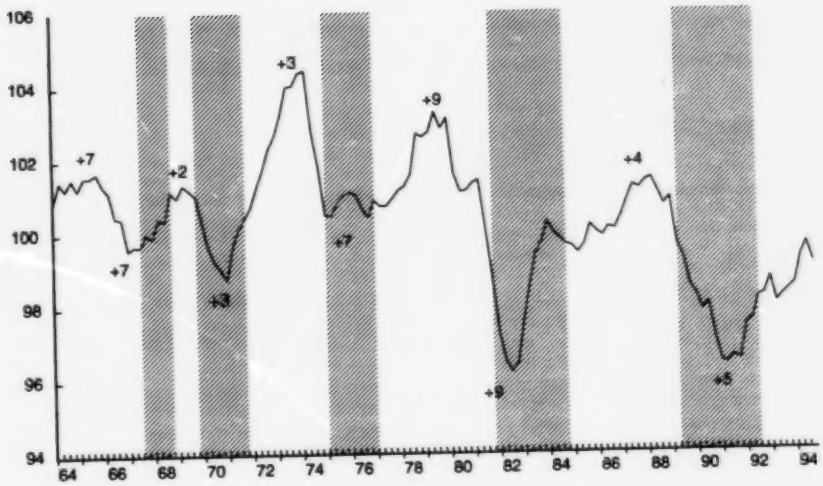
[27] We also constructed a leading index of inflation with non-equal weights, where the weights were determined in regression analysis. We found that allowing for variable weights did not improve the ex-post performance of the leading index in providing advance signals of cyclical turning points in inflation. Furthermore, we found some evidence of significant instability in the estimated weights. Finally, using a leading index of inflation with variable weights did not improve the estimation results of the indicator model described in Section II.1.

[28] The average lead at peaks for the Nesbitt-Burns Leading Indicator is 2.5 months (MacGregor and St-Cerny (1994)). In his study on leading indicators of inflation for the G-7 members, Klein reports a median lead of 6 months at peaks for Canada.

CHART 6

LEADING INDEX OF INFLATION FOR CANADA

(index 1986 = 100)



Note: The shade bars show the inflation cycle chronology.

TABLE 5:

TURNING POINTS SIGNALS

FROM THE LEADING INDEX OF INFLATION

Inflation Peaks		Inflation Troughs	
Date of Turning Point	Lead (+) or Lag (-)	Date of Turning Point	Lead (+) or Lag (-)
1967 Q1	+7	1968 Q4	+7
1969 Q4	+2	1973 Q4	+3
1975 Q1	+3	1977 Q1	+7
1981 Q4	+9	1984 Q4	+9
1989 Q2	+4	1982 Q3	+5
Turning Point Statistics			
Minimum	+2	Minimum	+3
Maximum	+9	Maximum	+9
Mean	+5	Mean	+6

We have not established rules to signal in advance a cyclical turning point in inflation. We have deliberately avoided this as we are primarily interested in forecasting the future rate of inflation, not just the probable timing of future cyclical turning points. Further, the shift in inflation regimes in the early 1980s makes it highly unlikely that such rules, derived over the whole sample period, would be relevant in the current period of relatively stable inflation and official inflation targets.[29] Finally, we do not have sufficient experience with the recent regime to confidently specify a set of rules specific to this regime.

V CONCLUSION

This paper presented an indicator, or non-structural, model of inflation that provides considerably more accurate forecasts than either a simple Phillips Curve model or an autoregressive model of inflation. While the model is not based on a firm theoretical foundation, it nevertheless captures most of the influences described in structural approaches.

A key benefit of our model of inflation is it provides forecasts which are based on real-time data, and it does not rely on variables that are subject to considerable ex post adjustments or revisions. In particular, the indicator model includes a leading index of inflation, which has greater predictive power than any measure of the output gap, but suffers from none of the measurement problems associated with estimates of the output gap.

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[29] The existence of inflation targets likely mean that the Bank of Canada now cares more about the variance of inflation than it did before 1992.

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Annex 1:
Recursive Tests for Indicator Model

Chart A1
Cumulated Sums of Recursive Residuals

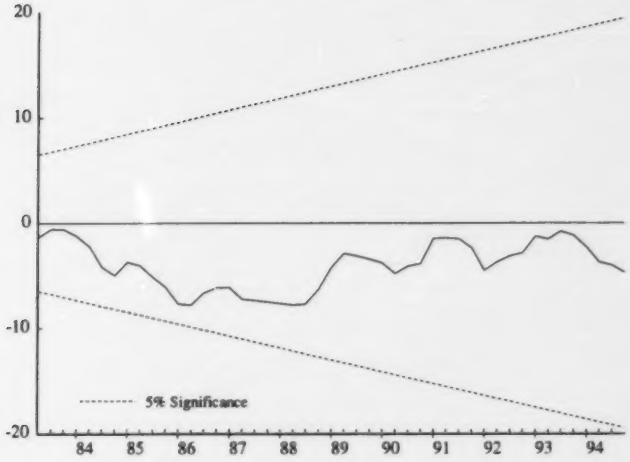
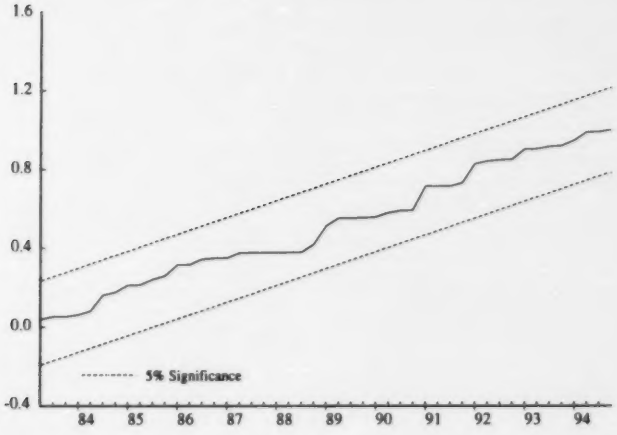


Chart A2
Cumulated Sums of Square Recursive Residuals



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